BACKGROUND OF THE INVENTION

(0001) In the inboard motor boating industry there is a need to seal the propeller drive shaft where it passes through the hull of the boat. In the field of large vessels it had been common practice to employ a "stuffing box" to seal the propeller drive shaft. These packing seals were prone to leak and a constant source of maintenance problems for the boat operators.

(0002) The stuffing box seal caused environmental concerns in boating applications. The inherent friction between the drive shaft and the packing material required a constant low volume flow of lubricating oil to the seal. Even when properly maintained oil would seep through the seal and contaminate the water.

(0003) Recent advances in composite materials have made it possible to do away with the stuffing box. The water seal is now being maintained by a precisely machined and polished composite material face driven against a stationary split ring face seal on the stern tube.

(0004) SUMMARY OF THE INVENTION

The present invention relates to advances in composite material seal facings that allow for a more efficient system that is easier to maintain. The seal is a split ring which is necessary for large vessel drive lines typically those with a drive shaft diameter over 3 inches. The present device allows the seal to be serviced as necessary without removal of the entire propeller shaft drive assembly.

(0005)A drive line having a split ring face seal including a split ring face seal of self lubricating material is formed from two half rings joined at two polished surfaces.

A seal face on said split ring face seal, and the split ring face seal having an inside diameter and an outside diameter with a rotatable drive shaft passing through the inside diameter of the seal face. The split ring face seal includes a plurality of raised fiber bearing surfaces integrally formed on the inside diameter of the split ring face seal such that relative movement between the split ring face seal and the drive shaft can cause the raised fiber bearing surfaces to contact the outside diameter of said drive shaft to keep the split ring face seal centered.

(0006) BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 Shows a view of the seal

Figure 2 Shows an edge view of the seal

Figure 3 Shows a cross sectional view of the seal installed in a boat drive line

Figure 4 Shows a cross sectional view of details of manufacturing the seal face

Figure 5 Shows an exterior view of the drive line

Figure 6 Shows a prior art seal and;

Figure 7 Shows a cross section of the prior art seal assembly

(0007) DETAILED DESCRIPTION OF THE DEVICE

(0008)Figure 1 shows a face on view of the back surface split ring face seal (10). The split ring face seal (10) is made in two separate halves joined at polished facings (12). The face seal (10) includes a plurality of raised bearing surfaces (14) on the inside diameter (22) of the seal (10), machined simultaneously as the face seal (10) is being created. The plurality of raised bearing surfaces (14) form a gapped inner most diameter

(24) (shown as a dashed line) that allows for water to flow around the outside diameter of drive shaft (101 in Figure 3). The face seal (10) includes a plurality of threaded bolt holes (18) and at least one drive pin hole (20). The material used for the face seal (10) can be any dense, stable, self- lubricating composite such as a graphite- impregnated fiber. One such material goes by the commercial name of Simsite. Figure 2 shows a cross sectional edge on view of the face seal (10). The cross section shows surface (30) and seal face (32). Shoulder diameter (34) provides a location for a compression band (shown in Figure 3, 124), preferably of nitrile, that holds the split ring face seal (10) together during assembly of the split ring face seal (10). Shoulder (39) provides a surface for the thrust boot (110 shown in Figure 3) to seat on and groove (38) can aid in maintaining a clean face surface on seal face (32). The groove (38) helps wash away sediment that may get on face (108) before it can become trapped between faces (108) and (32).

(0009) Figure 3 shows a cross sectional view of the face seal (10) and boat drive line (100). The drive shaft (101) drives a propeller (102) outside the stern tube (104) of the boat. The stern tube (104) includes a mating ring (106) that is typically a coated carbide, stainless steel or similar corrosion and wear resistant material. The mating ring (106) can be pinned to the stern tube (104) and held to the stern tube (104) by compression from the thrust boot (110). The fixed face (108) of the ring (106) contacts the moving face (32) (shown in figure 2) of the split ring seal (10). The interface of fixed face (108) and moving face (32) form the water tight mechanical seal between the rotating drive shaft (101) and the fixed boat stern tube (104). The drive shaft arrangement includes a solid rubber thrust boot (110). This rubber thrust boot (110) is clamped to the drive shaft

(101) by a split ring steel clamp (120) and turns with it when the drive shaft (101) is rotating. During installation of the split ring face seal (10), the thrust boot (110) is axially compressed and then held by the clamp (120) and secured by bolts (122, Figure 5) so that the thrust boot (110) holds the face seal (10) and ring (106) in compression against each other and against the stern tube (104). The thrust boot (110) includes an integrally molded brass ring (112) that stiffens the boot (110) and carries a drive pin (114). The drive pin (114) drives the face seal (10), which rotates with the drive shaft (101). The seal arrangement includes a nitrile rubber compression band (124) wrapped around the split ring face seal (10). The nitrile rubber compression band (124) holds the face seal (10) together and in place during assembly and provides a water tight seal for the brass ring (112) of the boot (110) against the face seal (10). A similar arrangement seals the back of the stationary ring (106) to the stern tube (104). Figure 3 also shows that the sealing arrangement forms a hollow area (300) that in use will be filled with water. There are several sealing joints but only the planar surface between face seal (10) and the stern tube ring (106) forms a mechanical self lubricating seal between two parts moving relative to one another. The fixed face (108) and moving face (32) must match up perfectly to avoid leaks.

(0010)Figure 4 shows a portion of the manufacturing process for the split ring face seal (10). The face seal (10) starts out as a cylindrical or ring shaped fiber material blank (200) shown in phantom lines. The back surface (30) is machined and polished. The blank (200) can be split and the facings (12 in Figure 1) between the two halves are accurately machined and polished. Threaded holes (18) are installed in the back surface (30) of the blank (200) so that the split blank (200) can be mounted on a fixture (310)

using bolts (314), stainless steel inserts (not shown) can be used for holes (18). The fixture (310) can then be attached, using bolts (312) to the rotatable master fixture (300) which can be mounted in the rotatable chuck of a lathe (316). Once mounted the critical diameters (14,16) and moving face (32) of face seal (10) may be concentrically turned from the blank (200). This process assures the parallelism of thrust shoulder (39) and seal moving face (32). After all turning and facing processes are complete, the critical sealing surface moving face (32) is polished while the split ring face seal (10) is turning counter clockwise in the lathe (316). Course abrasive can be used in a first rough polish step. Then the direction of rotation of the lathe (316) can be reversed during course abrasive and then the next finer polish grit is applied. The direction of rotation can be reversed with each finer grit abrasive until the surface is finished. The blank (200) can be rotated clockwise and counterclockwise with each grit. This process of reversing allows for a much finer finish to be achieved with the fiber faces then would be possible if the same direction of rotation were maintained throughout the polishing process. The polishing process removes all traces of composite fiber base from the seal face (32). The process also enables the thrust shoulder (39) and seal face (32) to be machined and polished perfectly parallel to each other maintaining a flatness tolerance of plus or minus .0001 inches on the seal face (32). This process is far superior to polishing or lapping with a unidirectional method (lathe turning one direction) which allows remnants of the fiber base to remain on the seal face (32) preventing a water tight seal between the mating faces (32 and 108).

(0011)One advantage of a split ring face seal is that it can be removed from around a large drive shaft (101) when it is worn and a replacement face seal (10) installed without

going to the time and expense of pulling the entire drive shaft (101). Figure 4 also demonstrates the ability to reface worn face seals (10). In the case of refacing a seal (10) that is worn, the split ring face seal (10) is re-installed on the fixture (310) after it is removed from a boat, using original bolt holes (18). The face seal (10) is then re-machined and polished to regain the .0001inch flatness tolerance and mirror smooth finish required for this application. This manufacturing process is critical to the application allowing for finishes, flatness and parallelism that give the face seal (10) a much longer life then current seals in the same application. The process also allows re-manufactured seals which saves substantially over the original cost of the face seal (10) which can cost several thousand dollars each. Typically both the stationary ring (106) and rotating face seal (10) are serial numbered and maintained as a matched pair and can be reconditioned/ refaced at the same time.

(0012) Figure 5 shows an exterior view of the drive line (100) including the face seal (10) as it would appear in a boat prior to disassembly. The drive shaft (101) powers the propeller (102) on the exterior of the boat stern tube (104). The stern tube (104) provides a mounting surface for the opposing stationary split ring (106), which can be tungsten carbide, with a fixed face surface (108) that acts as half of the sealing structure. The rubber boot (110) is held in compression by the steel split ring clamp (120) which is bolted (122) in place and turns with the drive shaft (101).

(0013)Figure 6 shows the prior art seal (510). The prior art seal (510) does not include bolts holes in the original manufacture so it is not possible to re-surface the sealing face after use. It is not practical to attempt to install holes (108) in a face seal (510) that did not original have them. The prior art seal (510) used Delrin inserts (514) as bearing

elements against the drive shaft (101). It was discovered that inserts (514) were undesirable because they wear into the drive shaft (101) over time weakening the shaft (101) and reducing the effectiveness of the bearing surface (14).

(0014)Figure 7 gives more detail on the operation of the prior art face seal (510). The prior art seals require water lubrication. Water from near the drive shaft (500) is pumped via pump (550) through line (552) through the stern tube (504) to line (554) that opened into the seal face (508) on tungsten carbide ring (506). A slot opening (560) circulates water around the face of ring (510) to lubricate. The water is necessary to keep the seal surface cool and because the prior art seal material is not self lubricating. Like the current device thrust boot (530) and clamp (522) maintain the sealing arrangement in compression. This prior art arrangement is undesirable because of the added expense and maintenance of the pump (550) but also because pumping water, even filtered water, will contaminate the polished seal faces and lead to failure of the seal (510).

(0015)Referring again to Figure 3, in use the face seal (10) would typically be placed in a fairly large vessel such as a tow boat. The drive line (100) powers the propeller (102) and the void (300) fills with water which must be sealed out of the boat. The mechanical seal between moving parts occurs between the ring (106) fixed face (108) and the split ring face seal (10) moving face (32). The rubber boot (110) is compressed and holds the face seal (10) against the ring (106). Tow boat operation involves frequent shifts in the application of power through the drive line (100), often going from forward to reverse and back in quick succession. Under such loading the rubber boot (110) and drive shaft (101) flexes and can cause the bearing surfaces (14) to come up against the drive shaft (101). Prior art seals as shown in figure 6 used Delrin inserts (514) as the

wear surface between the face seal (510) and the drive shaft during these shifts. These Delrin inserts (514) require a separate manufacturing process and are not diametrically accurate and interact with the shafting material in a way which damages the shaft. The Delrin inserts (514) have a small surface area and require a special operation to drill a hole and insert them into the seal (510). The current invention replaces these inserts (514) with integrally formed bearing surfaces (14). The bearing surfaces (14) are formed on a rotary table in a milling machine (not shown) while the face seal (10) is still attached to the fixture (310) which is attached to a master milling fixture (not shown) similar to the lathe fixture (300). The bearing surfaces (14) can be as large as required for bearing wear and yet still provide for the flow of water around the drive line (100). Part of the function of the bearing surfaces (14) is to keep any portion of the seal face (32) from coming off the face (108) and becoming exposed to water. Exposure to dirty water would accelerate the wear of the moving face (32) and fixed face (108). The bearing surfaces (14) keep the face seal (10) centered around the drive shaft (101) during drive line (100) loading that might otherwise cause the face seal (10) to come off center.